What is claimed is:

1. An optical system for use in an optical pickup apparatus, comprising:

a chromatic aberration correcting element having a ring-shaped zonal structure including plural ring-shaped zones on at least one optical surface thereof in which neighboring ring-shaped zones are divided with a stepped section in such a way that one of the neighboring ring-shaped zones located apart from the optical axis has a longer optical path than the other one located closer to the optical axis, and

an objective lens to converge a light flux from the chromatic aberration correcting element onto an information recording plane of an optical disk and having a ring-shaped zonal structure including plural ring-shaped zones on at least one optical surface thereof in which neighboring ring-shaped zones are divided with a stepped section shaped in the optical axis direction in such a way that the stepped section causes a optical path difference between light fluxes having passed through the neighboring ring-shaped zones;

wherein the ring-shaped zonal structure of the chromatic aberration correcting element corrects a deviation

of a focal point caused by the objective lens due to a wavelength fluctuation of an incident light flux coming into the optical system; and

the ring-shaped zonal structure of the objective lens corrects a spherical aberration caused by the objective lens due to a wavelength fluctuation of an incident light flux coming into the optical system.

2. The optical system of claim 1, wherein the ring-shaped zonal structure of the objective lens corrects at least one of a spherical aberration caused by a magnification fluctuation of the objective lens due to a wavelength fluctuation of an incident light flux coming into the optical system and a spherical aberration caused by the wavelength dispersion of the objective lens due to a wavelength fluctuation of an incident light flux coming into the optical system.

3. The optical system of claim 1, wherein the width of a ring-shaped zone in the ring-shaped zonal structure of the objective lens is changed periodically as the ring-shaped zone is located apart from the optical axis and the ring-

shaped zonal structure is a diffractive structure in which each stepped section is shaped in the same direction:

4. The optical system of claim 3, wherein when the optical path difference provided by the ring-shaped zonal structure to a wavefront passing through the objective lens is represented by an optical path difference function Φ_b defined by the formula of ($\Phi_b = b_2 \cdot h^2 + b_4 \cdot h^4 + b_6 \cdot h^6 + \ldots$) as a function of a height h (mm) from the optical axis (where b_2, b_4, b_6 are second, fourth, sixth order optical path difference function coefficients respectively), at least one optical path difference function coefficient including fourth order optical path difference function coefficient among high order optical path difference function coefficients of fourth order or more has a value other than zero.

5. The optical system of claim 4, wherein the following formula is satisfied:

$$-0.02 < P_D < 0.02$$

$$P_D = -2 \cdot b_2$$

Where P_D is the paraxial power (mm^{-1}) of the ring-shaped zonal structure formed on the objective lens.

6. The optical system of claim 5, wherein $P_D = 0$.

7. The optical system of claim 3, wherein the optical surface of the objective lens on which the ring-shaped zonal structure is formed includes a central region and a peripheral region, the central region includes the optical axis and is a continuous surface having no stepped section and the peripheral region encloses the periphery of the central region and has the stepped sections.

8. The optical system of claim 7, wherein the following formula is satisfied:

$$D1/D2 > 0.2$$

where D1 is the diameter of the central region, and

D2 is the maximum effective diameter of the optical surface on which the ring-shaped zonal structure is formed.

9. The optical system of claim 1, wherein the width of a ring-shaped zone in the ring-shaped zonal structure of the objective lens is changed non-periodically as the ring-shaped zone is located apart from the optical axis and the ring-shaped zonal structure is an optical path difference

providing structure in which the shaping direction of the stepped section is reversed in the effective diameter of the objective lens.

10. The optical system of claim 9, wherein in the ring-shaped zonal structure, a ring-shaped zone neighboring to the outside of a ring-shaped zone including the optical axis is displaced in the optical axis direction so as to have a shorter optical path length than the ring-shaped zone including the optical axis, a ring-shaped zone located at the point of the maximum effective diameter is displaced in the optical axis direction so as to have a longer optical path length than a ring-shaped zone neighboring to an inside of the ring-shaped zone located at the point of the maximum effective diameter, and a ring-shaped zone located at the point of 75% of the maximum effective diameter is displace in the optical axis direction so as to have a shorter optical path length that each of ring-shaped zones neighboring to the outside and inside of the ring-shaped zone located at the point of 75% of the maximum effective diameter.

11. The optical system of claim 9, wherein the following formula is satisfied:

$D3/D4 > 0.2$

where D3 is the diameter (mm) of the ring-shaped zone including the optical axis, and

D4 is the maximum effective diameter (mm) of the optical surface of the objective lens.

12. The optical system of claim 1, wherein the following formula is satisfied:

$\Delta SAR > \Delta SAD$

where, when it is defined that a refractive lens has not the ring-shaped zonal structure and has the same design wavelength, the same material, the same focal length, the same image-side numerical aperture, the same magnification, the same lens thickness and the same back focus as those of the objective lens, ΔSAR is a change amount of the spherical aberration of a marginal ray when a light flux having a wavelength longer by 10 nm than the design wavelength comes into the refractive lens, for the spherical aberration of a marginal ray when a light flux having the design wavelength comes into the refractive lens, and ΔSAD is a change amount of the spherical aberration of a marginal ray when a light flux having a wavelength longer by 10 nm than the design

wavelength comes into the objective lens, for the spherical aberration of a marginal ray when a light flux having the design wavelength comes into the objective lens.

13. The optical system of claim 1, wherein the following formula is satisfied:

$$\Delta SAD < 0$$

where ΔSAD is a change amount of the spherical aberration of a marginal ray when a light flux having a wavelength longer by 10 nm than the design wavelength comes into the objective lens, for the spherical aberration of a marginal ray when a light flux having the design wavelength comes into the objective lens.

14. The optical system of claim 1, wherein the following formula is satisfied:

$$|\Delta WFE1| < 0.03\ \lambda\ \mathrm{rms}$$

where $\Delta WFE1$ is a change amount of a wavefront aberration when a light flux having a wavelength longer by 10 nm than the design wavelength comes through the chromatic aberration correcting element into the objective lens, for a wavefront aberration when a light flux having the design wavelength

comes through the chromatic aberration correcting element into the objective lens.

15. The optical system of claim 1, wherein the objective lens is a single lens.

16. The optical system of claim 1, wherein the objective lens is composed of a diffractive element having the optical surface on which the ring-shaped structure is formed and a converging element to converge a light flux having passed the diffractive element, and the following formula is satisfied:

$$|P2/P1| < 0.2$$

where P1 is a paraxial power (mm^{-1}) of the diffractive element, and P2 is a paraxial power (mm^{-1}) of the converging element.

17. The optical system of claim 1, wherein the objective lens has an image-side numerical aperture of 0.7 or more.

18. The optical system of claim 1, wherein the design wavelength is 500 nm or less.

19. The optical system of claim 1, wherein the ring-shaped zonal structure of the chromatic aberration correcting element is a diffractive structure in which the width of a ring-shaped zone is periodically decreased as the ring-shaped zone is placed apart from the optical axis.

20. The optical system of claim 19, wherein when the optical path difference Φ_b provided to a wavefront passing through the chromatic aberration correcting element is represented by an optical path difference function Φ_b defined by the formula of ($\Phi_b = b_2 \cdot h^2 + b_4 \cdot h^4 + b_6 \cdot h^6 + \ldots$) as a function of a height h (mm) from the optical axis (where b_2, b_4, b_6 are second, fourth, sixth order optical path difference function coefficients respectively), the following formula is satisfied:

$$P_D > 0$$

where P_D is a paraxial power (mm^{-1}) of the ring-shaped zonal structure.

21. The optical system of claim 20, wherein all of high order optical path difference function coefficients not less

than fourth order in the optical path difference function Φ_b are zero.

22. The optical system of claim 1, wherein the ring-shaped zonal structure of the chromatic aberration correcting element is a optical path difference proving structure in which the width of a ring-shaped zone is changed non-periodically as the ring-shaped zone is located apart from the optical axis.

23. The optical system of claim 1, wherein the chromatic aberration correcting element is a coupling lens to convert a divergent angle of a divergent light flux emitted from a light source into an almost parallel light flux.

24. The optical system of claim 1, wherein the optical pickup apparatus comprises a coupling lens to convert a divergent angle of a divergent light flux emitted from a light source into an almost parallel light flux and the chromatic aberration correcting element is an expander lens of two lens groups provided on an optical path between the coupling lens and the objective lens.

25. The optical system of claim 1, wherein the optical pickup apparatus comprises a coupling lens to convert a divergent angle of a divergent light flux emitted from a light source into an almost parallel light flux and the chromatic aberration correcting element is an optical element of one lens group provided on an optical path between the coupling lens and the objective lens.

26. An optical pickup apparatus, comprising:

a light source; and

an optical system to converge a light flux from the light source onto an information recording plane of the optical information recording medium so as to conduct recording and/or reproducing information;

the optical system comprising:

a chromatic aberration correcting element having a ring-shaped zonal structure including plural ring-shaped zones on at least one optical surface thereof in which neighboring ring-shaped zones are divided with a stepped section in such a way that one of the neighboring ring-shaped zones located apart from the optical axis has a longer optical path than the other one located closer to the optical axis, and

an objective lens to converge a light flux from the chromatic aberration correcting element onto an information recording plane of an optical disk and having a ring-shaped zonal structure including plural ring-shaped zones on at least one optical surface thereof in which neighboring ring-shaped zones are divided with a stepped section shaped in the optical axis direction in such a way that the stepped section causes a optical path difference between light fluxes having passed through the neighboring ring-shaped zones;

wherein the ring-shaped zonal structure of the chromatic aberration correcting element corrects a deviation of a focal point caused by the objective lens due to a wavelength fluctuation of an incident light flux coming into the optical system; and

the ring-shaped zonal structure of the objective lens corrects a spherical aberration caused by the objective lens due to a wavelength fluctuation of an incident light flux coming into the optical system.

27. The optical pickup apparatus of claim 26, wherein the ring-shaped zonal structure of the objective lens corrects at least one of a spherical aberration caused by a magnification fluctuation of the objective lens due to a wavelength

fluctuation of an incident light flux coming into the optical system and a spherical aberration caused by the wavelength dispersion of the objective lens due to a wavelength fluctuation of an incident light flux coming into the optical system.

28. The optical pickup apparatus of claim 26, wherein the width of a ring-shaped zone in the ring-shaped zonal structure of the objective lens is changed periodically as the ring-shaped zone is located apart from the optical axis and the ring-shaped zonal structure is a diffractive structure in which each stepped section is shaped in the same direction.

29. The optical pickup apparatus of claim 28, wherein when the optical path difference provided by the ring-shaped zonal structure to a wavefront passing through the objective lens is represented by an optical path difference function Φ_b defined by the formula of ($\Phi_b = b_2 \cdot h^2 + b_4 \cdot h^4 + b_6 \cdot h^6 + \ldots$) as a function of a height h (mm) from the optical axis (where b_2, b_4, b_6 are second, fourth, sixth order optical path difference function coefficients respectively), at least one

optical path difference function coefficient including fourth order optical path difference function coefficient among high order optical path difference function coefficients of fourth order or more has a value other than zero.

30. The optical pickup apparatus of claim 29, wherein the following formula is satisfied:

$$-0.02 < P_D < 0.02$$

$$P_D = -2 \cdot b_2$$

Where P_D is the paraxial power (mm^{-1}) of the ring-shaped zonal structure formed on the objective lens.

31. The optical pickup apparatus of claim 30, wherein P_D = 0.

32. The optical pickup apparatus of claim 28, wherein the optical surface of the objective lens on which the ring-shaped zonal structure is formed includes a central region and a peripheral region, the central region includes the optical axis and is a continuous surface having no stepped section and the peripheral region encloses the periphery of the central region and has the stepped sections.

33. The optical pickup apparatus of claim 32, wherein the following formula is satisfied:

$D1/D2 > 0.2$

where D1 is the diameter of the central region, and

D2 is the maximum effective diameter of the optical surface on which the ring-shaped zonal structure is formed.

34. The optical pickup apparatus of claim 26, wherein the width of a ring-shaped zone in the ring-shaped zonal structure of the objective lens is changed non-periodically as the ring-shaped zone is located apart from the optical axis and the ring-shaped zonal structure is an optical path difference providing structure in which the shaping direction of the stepped section is reversed in the effective diameter of the objective lens.

35. The optical pickup apparatus of claim 34, wherein in the ring-shaped zonal structure, a ring-shaped zone neighboring to the outside of a ring-shaped zone including the optical axis is displaced in the optical axis direction so as to have a shorter optical path length than the ring-shaped zone including the optical axis, a ring-shaped zone

located at the point of the maximum effective diameter is displaced in the optical axis direction so as to have a longer optical path length than a ring-shaped zone neighboring to an inside of the ring-shaped zone located at the point of the maximum effective diameter, and a ring-shaped zone located at the point of 75% of the maximum effective diameter is displace in the optical axis direction so as to have a shorter optical path length that each of ring-shaped zones neighboring to the outside and inside of the ring-shaped zone located at the point of 75% of the maximum effective diameter.

36. The optical pickup apparatus of claim 34, wherein the following formula is satisfied:

$$D3/D4 > 0.2$$

where D3 is the diameter (mm) of the ring-shaped zone including the optical axis, and

D4 is the maximum effective diameter (mm) of the optical surface of the objective lens.

37. The optical pickup apparatus of claim 26, wherein the following formula is satisfied:

$$\Delta SAR > \Delta SAD$$

where, when it is defined that a refractive lens has not the ring-shaped zonal structure and has the same design wavelength, the same material, the same focus length, the same image-side numerical aperture, the same magnification, the same lens thickness and the same back focus as those of the objective lens, ΔSAR is a change amount of the spherical aberration of a marginal ray when a light flux having a wavelength longer by 10 nm than the design wavelength comes into the refractive lens, for the spherical aberration of a marginal ray when a light flux having the design wavelength comes into the refractive lens, and ΔSAD is a change amount of the spherical aberration of a marginal ray when a light flux having a wavelength longer by 10 nm than the design wavelength comes into the objective lens, for the spherical aberration of a marginal ray when a light flux having the design wavelength comes into the objective lens.

38. The optical pickup apparatus of claim 26, wherein the following formula is satisfied:

$$\Delta SAD < 0$$

where ΔSAD is a change amount of the spherical aberration of a marginal ray when a light flux having a wavelength longer

by 10 nm than the design wavelength comes into the objective lens, for the spherical aberration of a marginal ray when a light flux having the design wavelength comes into the objective lens.

39. The optical pickup apparatus of claim 26, wherein the following formula is satisfied:

$$|\Delta WFE1| < 0.03\ \lambda\ \text{rms}$$

where $\Delta WFE1$ is a change amount of a wavefront aberration when a light flux having a wavelength longer by 10 nm than the design wavelength comes through the chromatic aberration correcting element into the objective lens, for a wavefront aberration when a light flux having the design wavelength comes through the chromatic aberration correcting element into the objective lens.

40. The optical pickup apparatus of claim 26, wherein the objective lens is a single lens

41. The optical pickup apparatus of claim 26, wherein the objective lens is composed of a diffractive element having the optical surface on which the ring-shaped structure is

formed and a converging element to converge a light flux having passed the diffractive element, and the following formula is satisfied:

$$|P2/P1| < 0.2$$

where P1 is a paraxial power (mm^{-1}) of the diffractive element, and P2 is a paraxial power (mm^{-1}) of the converging element.

42. The optical pickup apparatus of claim 26, wherein the objective lens has an image-side numerical aperture of 0.7 or more.

43. The optical pickup apparatus of claim 26, wherein the design wavelength is 500 nm or less.

44. The optical pickup apparatus of claim 26, wherein the ring-shaped zonal structure of the chromatic aberration correcting element is a diffractive structure in which the width of a ring-shaped zone is periodically decreased as the ring-shaped zone is placed apart from the optical axis.

45. The optical pickup apparatus of claim 44, wherein when the optical path difference Φ_b provided to a wavefront passing through the chromatic aberration correcting element is represented by an optical path difference function Φ_b defined by the formula of ($\Phi_b = b_2 \cdot h^2 + b_4 \cdot h^4 + b_6 \cdot h^6 + \ldots$) as a function of a height h (mm) from the optical axis (where b_2, b_4, b_6 are second, fourth, sixth order optical path difference function coefficients respectively), the following formula is satisfied:

$$P_D > 0$$

where P_D is a paraxial power (mm^{-1}) of the ring-shaped zonal structure.

46. The optical pickup apparatus of claim 45, wherein all of high order optical path difference function coefficients not less than fourth order in the optical path difference function Φ_b are zero.

47. The optical pickup apparatus of claim 26, wherein the ring-shaped zonal structure of the chromatic aberration correcting element is a optical path difference proving structure in which the width of a ring-shaped zone is changed

non-periodically as the ring-shaped zone is located apart from the optical axis.

48. The optical pickup apparatus of claim 26, wherein the chromatic aberration correcting element is a coupling lens to convert a divergent angle of a divergent light flux emitted from a light source into an almost parallel light flux.

49. The optical pickup apparatus of claim 26, wherein the optical pickup apparatus comprises a coupling lens to convert a divergent angle of a divergent light flux emitted from a light source into an almost parallel light flux and the chromatic aberration correcting element is an expander lens of two lens groups provided on an optical path between the coupling lens and the objective lens.

50. The optical pickup apparatus of claim 26, wherein the optical pickup apparatus comprises a coupling lens to convert a divergent angle of a divergent light flux emitted from a light source into an almost parallel light flux and the chromatic aberration correcting element is an optical element of one lens group provided on an optical path between the coupling lens and the objective lens.

51. The optical pickup apparatus of claim 26, wherein when at least one of recording and reproducing information for the optical information recording medium is conducted, a tracking is conducted by displacing only the objective lens in a direction perpendicular to the optical axis with an actuator among the chromatic aberration correcting element and the objective lens.

52. An objective lens for use in an objective lens, comprising:

a ring-shaped zonal structure including plural ring-shaped zones on at least one optical surface thereof in which neighboring ring-shaped zones are divided with a stepped section shaped in the optical axis direction in such a way that the stepped section causes a optical path difference between light fluxes having passed through the neighboring ring-shaped zones;

wherein the following formula is satisfied:

$SA1 > SA2$

where, when it is defined that a refractive lens has not the ring-shaped zonal structure and has the same design wavelength, the same material, the same focal length, the

same image-side numerical aperture, the same magnification, the same lens thickness and the same back focus as those of the objective lens, SA1 is a wavefront aberration (λrms) when a light flux having a wavelength longer by 10 nm than the design wavelength comes into the refractive lens with a magnification larger by a predetermined value than the above magnification, and SA2 is a wavefront aberration (λrms) when a light flux having a wavelength longer by 10 nm than the design wavelength comes into the objective lens with the magnification larger by the predetermined value than the above magnification.

53. The objective lens of claim 52, wherein the objective lens has an image-side numerical aperture of 0.7 or more.

54. The objective lens of claim 52, wherein the design wavelength is 500 nm or less.

55. The objective lens of claim 52, wherein the objective lens is a single lens.

56. The objective lens of claim 52, wherein the objective lens is composed of a diffractive element having the optical surface on which the ring-shaped structure is formed and a converging element to converge a light flux having passed the diffractive element, and the following formula is satisfied:

$$|P2/P1| < 0.2$$

where P1 is a paraxial power (mm^{-1}) of the diffractive element, and P2 is a paraxial power (mm^{-1}) of the converging element.

57. The objective lens of claim 52, wherein the width of a ring-shaped zone in the ring-shaped zonal structure is changed periodically as the ring-shaped zone is located apart from the optical axis and the ring-shaped zonal structure is a diffractive structure in which each stepped section is shaped in the same direction.

58. The objective lens of claim 57, wherein when the optical path difference provided by the ring-shaped zonal structure to a wavefront passing through the objective lens is represented by an optical path difference function Φ_b defined by the formula of ($\Phi_b = b_2 \cdot h^2 + b_4 \cdot h^4 + b_6 \cdot h^6 +$

…) as a function of a height h (mm) from the optical axis (where b_2, b_4, b_6 are second, fourth, sixth order optical path difference function coefficients respectively), at least one optical path difference function coefficient including fourth order optical path difference function coefficient among high order optical path difference function coefficients of fourth order or more has a value other than zero.

59. The objective lens of claim 58, wherein the following formula is satisfied:

$$-0.02 < P_D < 0.02$$

$$P_D = -2 \cdot b_2$$

Where P_D is the paraxial power (mm^{-1}) of the ring-shaped zonal structure formed on the objective lens.

60. The objective lens of claim 59, wherein $P_D = 0$.

61. The objective lens of claim 57, wherein the optical surface of the objective lens on which the ring-shaped zonal structure is formed includes a central region and a peripheral region, the central region includes the optical axis and is a continuous surface having no stepped section

and the peripheral region encloses the periphery of the central region and has the stepped sections.

62. The objective lens of claim 61, wherein the following formula is satisfied:

$$D1/D2 > 0.2$$

where D1 is the diameter of the central region, and

D2 is the maximum effective diameter of the optical surface on which the ring-shaped zonal structure is formed.

63. The objective lens of claim 62, wherein the following formula is satisfied:

$$D1/D2 > 0.3$$

64. The objective lens of claim 52, wherein the width of a ring-shaped zone in the ring-shaped zonal structure of the objective lens is changed non-periodically as the ring-shaped zone is located apart from the optical axis and the ring-shaped zonal structure is an optical path difference providing structure in which the shaping direction of the stepped section is reversed in the effective diameter of the objective lens.

65. The objective lens of claim 64, wherein in the ring-shaped zonal structure, a ring-shaped zone neighboring to the outside of a ring-shaped zone including the optical axis is displaced in the optical axis direction so as to have a shorter optical path length than the ring-shaped zone including the optical axis, a ring-shaped zone located at the point of the maximum effective diameter is displaced in the optical axis direction so as to have a longer optical path length than a ring-shaped zone neighboring to an inside of the ring-shaped zone located at the point of the maximum effective diameter, and a ring-shaped zone located at the point of 75% of the maximum effective diameter is displace in the optical axis direction so as to have a shorter optical path length that each of ring-shaped zones neighboring to the outside and inside of the ring-shaped zone located at the point of 75% of the maximum effective diameter.

66. The objective lens of claim 64, wherein the following formula is satisfied:

$$D3/D4 > 0.2$$

where D3 is the diameter (mm) of the ring-shaped zone including the optical axis, and

D4 is the maximum effective diameter (mm) of the optical surface of the objective lens.

67. The objective lens of claim 64, wherein the following formula is satisfied:

$$\Delta SAR > \Delta SAD$$

where, when it is defined that a refractive lens has not the ring-shaped zonal structure and has the same design wavelength, the same material, the same focus length, the same image-side numerical aperture, the same magnification, the same lens thickness and the same back focus as those of the objective lens, ΔSAR is a change amount of the spherical aberration of a marginal ray when a light flux having a wavelength longer by 10 nm than the design wavelength comes into the refractive lens, for the spherical aberration of a marginal ray when a light flux having the design wavelength comes into the refractive lens, and ΔSAD is a change amount of the spherical aberration of a marginal ray when a light flux having a wavelength longer by 10 nm than the design wavelength comes into the objective lens, for the spherical aberration of a marginal ray when a light flux having the design wavelength comes into the objective lens.

68. The objective lens of claim 52, wherein the following formula is satisfied:

$$|\Delta WFE1| < 0.03\ \lambda\ \mathrm{rms}$$

where ΔWFE1 is a change amount of a wavefront aberration when a light flux having a wavelength longer by 10 nm than the design wavelength comes into the objective lens, for a wavefront aberration when a light flux having the design wavelength comes into the objective lens.

69. The objective lens of claim 52, wherein the following formula is satisfied:

$$\Delta SAD < 0$$

where ΔSAD is a change amount of the spherical aberration of a marginal ray when a light flux having a wavelength longer by 10 nm than the design wavelength comes into the objective lens, for the spherical aberration of a marginal ray when a light flux having the design wavelength comes into the objective lens.